ST JOSEPH'S UNIVERSITY, BENGALURU-27

DEPARTMENT OF MATHEMATICS

Syllabus for Bachelor of Science Under
National Education Policy

For Batch 2022-25

Name of the Degree Programme **:** B.Sc./B.Sc.
Discipline Core **:** Mathematics
Starting year of implementation **:** 2022 -23

ST JOSEPH'S UNIVERSITY, BENGALURU
Syllabus for B.Sc. Mathematics

Name of the Degree Programme : B.Sc.
Discipline Course : Mathematics
Starting Year of Implementation : 2022-23

Programme Outcomes (PO)

By the end of the programme the students will be able to:

PO1	Disciplinary Knowledge: Bachelor's degree in mathematics is the culmination of in-depth knowledge of Algebra, Calculus, Geometry, Differential Equations and several other branches of pure and applied Mathematics. This also leads to a studyin related areas.
PO2	Communication Skills: Ability to communicate various Mathematical concepts effectively using examples and their geometric visualization. The skills and knowledge gained in this programme will lead to the proficiency in analytical reasoning which can be used for modelling and solving of real-life problems.
PO3	Critical thinking and analytical reasoning: The students undergoing this programme acquire the ability of critical thinking and logical reasoning and the capability of recognizing and distinguishing various aspects of real-life problems.
PO4	Problem Solving: The Mathematical knowledge gained by the students through this programme gives them an ability to analye the problems and identify or define appropriate computing techniques for their solutions. This programme enhances student's overall development.
PO5	Research related skills: Upon completing this programme the students will develop the capability of asking appropriate questions related to the Mathematical concepts in different areas of Mathematics.
PO6	Information / Digital Literacy: The completion of this programme will enable the learner to find, evaluate and effectively communicate knowledge related to certain mathematical topics using appropriate software.
PO7	Self–directed learning: The student completing this programme will develop an ability to work independently and to make an in-depth study of various notions of Mathematics.
PO8	Moral and ethical awareness / reasoning: The student, on completing this programme, will develop an ability to identify unethical behavior such as fabrication, falsification or misinterpretation of data and adopt objectives that are unbiased and truthful in all aspects of life in general and Mathematical Studies in particular.
PO9	Lifelong learning: This programme provides self-directed and lifelong learning skills. This programme helps the learner to think independently, develop algorithms and computational skills for solving real world problems.
PO10	Ability to pursue advanced studies and research in Pure and Applied MathematicalSciences.

ASSESSMENTS
Weightage for the Assessments (in percentage)

Type of Course	Formative Assessment (I.A.)	Summative Assessment (S.A.)
Theory	40%	60%
Practical	50%	50%
Projects	50%	50%

Contents of Courses for B.Sc. with Mathematics as Major Subject & B.Sc. (Hons) Mathematics
Model III A

Semester	Course No.			Paper Title	Marks	
					S.A.	I.A.
I	MT121	Theory	4	Mathematics–I	60	40
	MT1P1	Practical	2	Mathematics Practical-I	25	25
	MTOE-1 MTOE-2 MTOE-3	Theory	3	(A) Business Mathematics (B) Mathematics for Physical Sciences-I (C) Quantitative Methods for Competitive Examinations	60	40
II	MT221	Theory	4	Mathematics–II	60	40
	MT2P1	Practical	2	Mathematics Practical-II	25	25
	MTOE-4 MTOE-5 MTOE-6	Theory	3	(A) Mathematics for Life Sciences-I (B) Mathematics for Physical Sciences-II (C) Mathematics for Management Aptitude Tests	60	40
Exit Option with Certificate						

Semester	Course No.		Paper Title		Marks	
					S.A.	I.A.
III	MT322	Theory	4	Mathematics–III	60	40
	MT3P1	Practical	2	Mathematics Practical-III	25	25
	MTOE-7 MTOE-8 MTOE-9	Theory	3	(A) Graphs and their real-life applications (B) Mathematics for Physical Sciences-III (C) Mathematics for Life Sciences-II	60	40
IV	MT422	Theory	4	Mathematics–IV	60	40
	MT4P1	Practical	2	Mathematics Practical-IV	25	25
	MTOE-10 MTOE-11 MTOE-12	Theory	3	(A) How to make Right Decision (B) Mathematics for Physical Sciences-IV (C) Wealth Management	60	40
Exit Option with Diploma						
V	MT-5123	Theory	3	Mathematics–V	60	40
	MT5P1	Practical	2	Mathematics Practical-V	25	25
	MT 5223	Theory	3	Mathematics–VI	60	40
	MT5P2	Practical	2	Mathematics Practical-VI	25	25
VI	MT6123	Theory	3	Mathematics–VII	60	40
	MT6P1	Practical	2	Mathematics Practical-VII	25	25
	MT6223	Theory	3	Mathematics–VIII	60	40
	MT6P2	Practical	2	Mathematics Practical-VIII	25	25
Exit Option with Degree						

EXAMINATION AND ASSESMENTS

THEORY

I.A. Weightage 40 %

End Semester Examination Weightage 60 %

PRACTICAL/PROJECTS

I.A. Weightage 50 %

End Semester Examination Weightage 50 %

Title	Credits	CA Marks	SE Marks	Total marks	Max Marks for ESE	Time Duration for ESE
Core Subjects	4	40	60	100	60	2 Hrs
Department Electives	4	40	60	100	60	2 Hrs
Open Electives	3	40	60	100	60	2 Hrs
Practical	2	25	25	50	25	3 Hrs

Title	Credits	Max marks	Written	MCQ	Total time
Core and Department Electives	4	100	100		3 Hrs
Open Elective	3	60	60	-	2 Hrs
Open Elective	3	60		60	1 ½ Hrs

INTERNAL ASSESSMENT FORMAT

THEORY:

1. First Activity 10 marks
2. Mid Semester Test (Test will be for 25 marks. It will be converted to 20) 20 marks
3. Second Activity 10 marks

Total **40 marks**

PRACTICAL:

Every practical class the student should be assessed.

PIA 25 marks

Syllabus for B.Sc. with Mathematics as Major Subject &
B.Sc. (Honours)Mathematics

SEMESTER– I

MT121: Mathematics-I	
Teaching Hours: 4 Hours / Week	Credits: 4
Total Teaching Hours: 56 Hours	Max. Marks: 100 (S.A: 60 + I.A: 40)

Course Learning Outcomes: This course will enable the students to

- Find the rank of a matrix.
- Solve the system of homogeneous and non-homogeneous linear equations in 'n' variables by using concept of rank of matrix, finding eigenvalues and eigenvectors.
- Familiarize with the techniques of finding n^{th} derivatives of standard functions.
- Identify and apply the intermediate value theorems and L'hospital's rule.
- Differentiate partially along with its applications.

Unit-I: Algebra-I

Matrices: Recapitulation of Symmetric and Skew Symmetric matrices, Algebra of Matrices; Row echelon form and row reduced echelon form. Rank of a matrix; Finding rank of a matrix by reducing to row echelon form and normal form; Solution of system of linear equations; Criteria for existence of non-trivial solutions of homogeneous system of linear equations. Solution of non-homogeneous system of linear equations. Eigenvalues and Eigenvectors of square matrices, standard properties; Cayley-Hamilton theorem and its applications. **14 Hours**

Calculus-I

Unit-II:

Limits, Continuity, Differentiability and Properties of continuous functions. nth Derivatives of Standard functions e^{ax+b}, $(ax+b)^n$, $\log(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $e^{ax}\sin(bx+c)$, $e^{ax}\cos(bx+c)$. Leibnitz theorem and its applications. **14 Hours**

Unit-III:

Intermediate value theorem, Rolle's Theorem, Lagrange's Mean Value theorem, Cauchy's Mean value theorem and examples. Taylor's theorem, Maclaurin's series, Indeterminate forms and evaluation of limits using L'Hospital's rule. **14 Hours**

Unit-IV: **Partial Differentiation**

Functions of two or more variables - explicit and implicit functions, partial derivatives. Homogeneous functions- Euler's theorem, total derivatives, differentiation of implicit and composite functions, Jacobians and standard properties and illustrative examples. Taylor's and Maclaurin's series for functions of two variables, Maxima-Minima of functions of two variables. **14 Hours**

Reference Books:

1. B S Vatsa, *Theory of Matrices*, New Age International Publishers.
2. A R Vasista, *Matrices*, Krishna Prakashan Media.
3. R. K. Ghosh, K. C. Maity, *An Introduction to Analysis Differential Calculus Part - I*, 13th Edition, New Central Book Agency Pvt. Ltd., 2018.
4. S. Bandyopadhyay, S. K. Maity, *Application of Calculus Theory and Problems*, 4th Edition,Academic Publishers, 2019.
5. Shanti Narayan, *Differential Calculus*, S. Chand & Company, New Delhi.
6. Lipman Bers, *Calculus*, Holt, Rinehart & Winston.
7. S Narayanan & T. K. Manicavachogam Pillay, *Calculus – Volume I and II*, S.Viswanathan (Printers & Publishers) Pvt Limited.

Blueprint (2 hours exam)

	Unit-I and Unit-II (Pre-midterm)	**Unit-III and Unit-IV (Post- midterm)**	**Number of Questions to be answered**	**Total**
Part A (2 Marks)	3	5	6 / 8	12
6 Marks	Part B 3 / 4 (2+2)	Part C 5 / 7 ($3\frac{1}{2}$+ $3\frac{1}{2}$)	8 /11	48
Total				**60**

Note: The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

MT1P1: Mathematics Practical–I	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Marks: 50 (S.A: 25+ I.A: 25)

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on algebra and calculus theory studied in MT121 by using FOSS
- Acquire knowledge of applications of algebra and calculus through FOSS.

Practical / Lab Work to be performed in Computer Lab (FOSS)
Suggested Software: Python.

Practical-I

1. Basics of software with simple examples.
2. Matrices: Algebra of Matrices with problems.
3. Computation of rank of a matrix by row reduced echelon form and normal form.
4. Solving the system of homogeneous and non-homogeneous linear equations.
5. Finding the n^{th} derivatives of functions without Leibnitz theorem.
6. Finding the n^{th} derivatives of functions with Leibnitz theorem.
7. Partial Differentiation of some standard functions and Jacobians.
8. Verification of Euler's theorem with examples.
9. Indeterminate forms and evaluation of limits using L'Hospital's rule.
10. Finding the maxima and minima of functions of two variables.

Note: Each problem given in the Lab Manual has to be solved manually.

SEMESTER– II

MT221: Mathematics - II	
Teaching Hours: 4 Hours/Week	Credits: 4
Total Teaching Hours: 56 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to

- Familiarise with algebraic structures.
- Link the fundamental concepts of groups and symmetries of geometrical objects.
- Understand the application of differentiation.
- Find the extreme values of functions of two variables.
- Understand the concept of differential equation and its application.

Unit-I: Algebra-II

Groups-I: Definition of a group with examples and properties, congruence, problems. Subgroups, centre of groups, order of an element of a group and its related theorems, cyclic groups. **14 Hours**

Unit-II: Calculus-II

Integral Calculus

Recapitulation of definite integrals and its properties. Reduction formulae - $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \sin^m x \cos^n x \, dx$ with limits, problems, computation of length of an arc, Area of plane curves, surface area and volume of revolution in Cartesian and polar forms. **14 Hours**

Unit-III:

Polar coordinates, angle between the radius vector and tangent. Angle of intersection of two curves (polar forms), length of perpendicular from pole to the tangent, pedal equations. Derivative of an arc in Cartesian, parametric and polar forms, curvature of plane curve-radius of curvature formula in Cartesian, parametric and polar and pedal forms-centre of curvature, asymptotes, evolutes and envelops. **14 Hours**

Unit-IV: Differential Equations-I

Recapitulation of Solutions of ordinary differential equations of first order and first degree. Formation of differential equations. Solutions of: Linear equations, Bernoulli's equation, Exact equations, reducible to Exact Equations of first order and higher degree. Applications of first order differential equations. Orthogonal trajectories in Cartesian and polar forms. **14 Hours**

Reference Books:

1. J. A. Gallian, *Contemporary Abstract Algebra*, 4th Edition, Narosa Publishing, 2011.
2. Bernard & Child, *Higher Algebra*, Arihant, ISBN: 9350943199/ 9789350943199.
3. Sharma and Vasista, *Modern Algebra*, Krishna Prakashan Mandir, Meerut, U.P.
4. S. K. Mapa, *Higher Algebra Abstract & Linear*, 14th Edition, Levant Books, 2019.
5. R. K. Ghosh K. C. Maity, *An Introduction to Analysis Differential Calculus Part - I*, 13th Edition, New Central Book Agency Pvt. Ltd., 2018.
6. S. Bandyopadhyay, S. K. Maity, *Application of Calculus Theory and Problems*, 4th Edition, Academic Publishers, 2019.
7. Shanti Narayan, *Differential Calculus*, S. Chand & Company, New Delhi.
8. Shanti Narayan, P K Mittal, *Integral Calculus*, S. Chand and Co. Pvt. Ltd.,
9. Frank Ayres and Elliott Mendelson, *Schaum's Outline Series of Calculus*, 5th ed. USA: Tata McGraw-Hill., 2008.
10. S C Malik, *Mathematical Analysis*, Wiley Eastern.
11. Vijay K Khanna, S K Bhambri, *A Course in Abstract Algebra*, Vikas Publications.
12. V. Sundarapandian, *Ordinary and Partial Differential Equations with Laplace Transforms, Fourier Series and Applications*, Tata McGraw Hill Education Pvt., Ltd., 2013.
13. G. F. Simmons, *Differential Equation with Applications and Historical Notes*, 2nd Edition, McGraw-Hill Publishing Company, 1991
14. M. D. Raisinghania, *Ordinary and Partial Differential Equations*, S Chand and Co. Pvt. Ltd., 2014.

Blueprint (2 hours exam)

	Unit-I and Unit-II {Pre-midterm)	**Unit-III and Unit-IV (Post- midterm)**	**Number of Questions to be answered**	**Total**
Part A (2 Marks)	3	5	6 / 8	12
6 Marks	Part B 3 / 4 (2+2)	Part C 5 / 7 ($3\frac{1}{2}$+ $3\frac{1}{2}$)	8 /11	48
Total				**60**

Note: The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 75% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT2P1: Mathematics Practical - II	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50 (S.A: 25+I.A: 25)

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on algebra and calculus by using FOSS.
- Acquire knowledge of applications of algebra and calculus through FOSS.

Practical/Lab Work to be performed in Computer Lab.
Suggested Software: Python.

Practical -II

1. Constructing Cayley's table and testing commutativity for a given finite set.
2. A) Checking whether a given subset is a subgroup or not.
   B) Finding the generator of a group.
3. Solving problems using reduction formulae.
4. Finding the angle between the radius vector and tangent.
5. A) Finding the angle between two curves.
   B) Finding the arc length of a curve.
6. Tracing of standard curves in Cartesian and Polar forms.
7. Computing surface area.
8. Computing volume of revolution.
9. Finding the solution of differential equation and plotting-1.
10. Finding the solution of differential equation and plotting-2.

SEMESTER– III

MT322: Mathematics - III	
Teaching Hours: 4 Hours/Week	Credits: 4
Total Teaching Hours: 56 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to

- Familiarise with Cyclic group and Normal subgroup.
- Understand concepts of sequences of real numbers.
- Understand the method of solution of differential equation of second and higher order.
- Understand concepts of Laplace Transforms.

Unit-I: Groups-II

Cyclic groups and properties. Coset decomposition of a group. Index of a group. Lagrange's theorem. Consequences of Lagrange's theorem. Problems relating to number of generators of a cyclic group and subset of a cyclic group, Normal subgroups. Examples and problems. Quotient group.

14 hours

Unit-II: Sequences of Real Numbers:

Definition of sequence, Limit of a sequence, Algebra of limits of a sequence Convergent, divergent and oscillatory sequences, Sandwich theorem. Problems, Bounded sequences. Every convergent sequence is bounded, Converse is not true, Monotonic sequences and their properties, Problems using the properties. Cauchy's sequence, Results related to Cauchy's sequences. **14 Hours**

Unit-III: Differential Equations II

Second and higher order ordinary linear differential equations with constant Coefficients. Complementary function. Particular integrals (standard types). Simultaneous linear differential equations (two variables) with constant coefficients. Cauchy-Euler differential equations.

Solutions of second order ordinary linear differential equations with variables coefficients by the following methods.

(i) When a part of complementary function is given
(ii) Changing the independent variable
(iii) Changing the dependent variable
(iv) Variation of parameters
(v) Conditions for exactness and the solution when the equation is exact. **14 hours**

Unit IV: Laplace Transforms

Definition and basic properties- Laplace transform of some common functions -Basic properties of Laplace transform- Standard results-Laplace transform of periodic functions- Laplace transforms of derivatives and the integral of function-Convolution Theorem-Inverse Laplace Transform-Solving Ordinary Differential Equations using Laplace Transform.

14 hours

Recommended Books

1) J. A. Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa Publishing, 2011
2) J. B. Fraleigh, A first course in Abstract Algebra, 7th Edition Pearson Education India, 2002
3) I. N. Herstein, Topics in Algebra, 2nd Edition, Wiley, 1975
4) R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Edition, Wiley and Sons, 2010.
5) S. C. Malik and S Arora, Mathematical Analysis, New Age International Publishers.
6) V. Sundarapandian, Ordinary and Partial Differential Equations, Tata McGraw- Hill.
7) Shepley L. Ross, Differntial Equations, 3rd Edition, Wiley.
8) M. D. Raisinghania, Ordinary and Partial Differential Equations, S Chand and Co. Pvt. Ltd., 2014.
9) G. F. Simmons, Differential equation with Applications and historical notes, 2nd Edition, McGraw-Hill Publishing Company, 1991.
10) Raisinghania M.D., Laplace and Fourier Transforms. New Delhi, India: S. Chand and Co. Ltd, 1995
11) M.G. Smith, Laplace transform theory, The New University Mathematics Series, 1966.

Blueprint (2 hours exam)

	Unit-I and Unit-II {Pre-midterm)	**Unit-III and Unit-IV (Post- midterm)**	**Number of Questions to be answered**	**Total**
Part A (2 Marks)	3	5	6 / 8	12
6 Marks	Part B 3 / 4 (2+2)	Part C 5 / 7 ($3\frac{1}{2}$+ $3\frac{1}{2}$)	8 /11	48
Total				**60**

Note: The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT3P1: Mathematics Practical – III	
Practical Hours: 3Hours/Week	Credits: 2
Total Practical Hours: 33Hours	Max. Marks: 50 (S.A: 25+I.A: 25)

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on algebra and calculus by using FOSS.
- Acquire knowledge of applications of algebra and calculus through FOSS Practical/Lab Work to be performed in Computer Lab.

Practical/Lab Work to be performed in Computer Lab.

Suggested Software: Python.

Practical -III

1. a) Examples for finding left and right coset and finding the index of a group.
   b) Verification of Normality of a given subgroup.
2. Verification of Lagrange's and Fermat's theorem.
3. Illustration of convergent, divergent and oscillatory sequences.
4. Finding complementary function and particular integral of constant coefficient second and higher order ordinary differentialequations – I.
5. Finding complementary function and particular integral of constant coefficient second and higher order ordinary differentialequations – II.
6. Finding the solution of second and higher order ordinary differentialequations with variable coefficient – I.
7. Finding the solution of second and higher order ordinary differentialequations with variable coefficient – II.
8. Laplace Transforms and Inverse Laplace Transform.
9. Solving Differential Equations with Laplace Transforms.
10. Calculating the convolution of two functions with Python.

MT422: Mathematics – IV	
Teaching Hours: 4 Hours/Week	Credits: 4
Total Teaching Hours: 56 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to

- Understand the concepts of homomorphism and isomorphism of groups.
- Understand concepts of series of real numbers.
- Understand the concept Fourier series and Beta and Gamma functions
- Understand concepts of numerical methods.

Unit-I: Groups-III

Homomorphism and Isomorphism of groups, Kernel and image of a homomorphism, Normality of the Kernel-Fundamental theorem of homomorphism, Isomorphism, Properties related to isomorphism of groups. Permutation group, Cayley's theorem. **8 hours**

Unit II: **Series of Real Numbers:**

Definition of convergence, divergence and oscillation of series-Properties of Convergent Series. Properties of Positive terms of Series, Geometric Series. Tests of series for convergence, p-series, Comparison test of series of convergence: Cauchy's root Test, D'Alembert's test, Raabe's test, Absolute and conditional convergence. D'Alembert test for absolute convergence, Alternating series, Leibnitz test. **14 hours**

Unit III:(a) Fourier Series

Trigonometric Fourier series of functions with period 2π and period $2L$. Half range Cosine and sine series. **7 hours**

(b) Beta and Gamma functions

Definition of Beta and Gamma functions (without proof of convergence of integral). Properties of beta and gamma functions. Relation between beta and gamma functions. **7 hours**

Unit IV: Numerical Methods

Interpolation:

- with equal intervals: Newton Gregory Forward and Backward Interpolation.
- with unequal intervals: Lagrange's and Newton's divided difference formula.

Numerical Integration:

- Newton-Cote's quadrature formula in terms of n (a general quadrature formula).
- Particular cases: Trapezoidal rule (n=1), Simpson's 1/3rd rule (n=2), Simpson's 3/8th rule (n=3).

Solution of algebraic equation by Bisection method, Regula-Falsi method, Newton-Raphson method, Secant method.

Numerical Solution of Ordinary Differential Equation: Euler's method, modified Euler's method, Runge-Kutta method of 4th order. **20 hours**

Recommended Books

1. Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa Publishing, 2011.
2. B.S. Grewal, Numerical Methods in Engineering and Science, Tenth Edition, Khanna Publishers, 2014.
3. J. B. Fraleigh, A first course in Abstract Algebra, 7th Edition Pearson Education India, 2002.
4. N. Herstein, Topics in Algebra, 2nd Edition, Wiley, 1975.
5. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Edition, Wiley and Sons, 2010.
6. S. C. Malik and S. Arora, Mathematical Analysis, New Age international publishers.
7. P.B. Patil and U.P. Varma, Numerical computational Methods, Narosa Publishing House 2009.
8. Saumyen Guha and Rajesh Srivasthava, Numerical Methods for Engineering and Science, Oxford University Press 2010.
9. P.Sivaramakrishna Das and C.Vijayakumari, Numerical Methods, Pearson 2013.
10. S. S. Sastry, Introductory Methods of Numerical Analysis, Fifth Edition, PHI Learning Private Ltd., 2017.
11. R L Burden and J D Faires, Numerical Analysis, Brooks/Cole, 9th edition, 2011.
12. S.R.K Iyenkar and R.K Jain, Numerical methods.
13. M. D. Raisinghania, Ordinary and Partial Differential Equations, S Chand and Co. Pvt. Ltd., 2014.

Blueprint (2 hours exam)

	Unit-I, Unit-II and 6hrs portion from Unit IV (Pre-midterm)	**Unit-III and Unit-IV (Post- midterm)**	**Number of Questions to be answered**	**Total**
Part A(2 Marks)	3	5	6 / 8	12
6 Marks	Part B 3 / 4 (2+2)	Part C 5 / 7 ($3\frac{1}{2}$+ $3\frac{1}{2}$)	8 /11	48
Total				**60**

Note: The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT4P1: Mathematics Practical – IV	
Practical Hours: 3Hours/Week	Credits: 2
Total Practical Hours: 33Hours	Max.Marks:50 (S.A: 25+I.A: 25)

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on algebra and calculus by using FOSS.
- Acquire knowledge of applications of algebra and calculus through FOSS Practical/Lab Work to be performed in Computer Lab.

Practical/Lab Work to be performed in Computer Lab.

Suggested Software: Python.

Practical -IV

1. Illustrating homomorphism and isomorphism of groups.
2. Illustration of convergent, divergent and oscillatory series.
3. Testing the convergence of binomial, exponential and logarithmic series and finding the sum.
4. A) Interpolations with equal intervals.
   B) Interpolations with unequal intervals.
5. Evaluate the integrals using
   A. Trapezoidal rule.
   B. Simpson's 1/3rd rule.
   C. Simpson's 3/8th rule.
6. Solving algebraic equation (Bisection method and Newton-Raphson method).
7. A. Solving ordinary differential equation by modified Euler's method.
   B. Solving ordinary differential equation by Runge-Kutta method of 4^{th} order.
8. Beta Gamma function.
9. Fourier series.
10. Half-range series.

Semester – V

MT5123: Mathematics – V	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 42 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to:

- Define fundamental concepts like rings, integral domains, fields, quotient rings and its properties.
- Understand the fundamental theorem of homomorphism of rings.
- Solve optimisation problems that naturally arises in various real-life situations.

Unit I: RING THEORY

Motivation and definition of rings. Examples of rings. Properties of rings. Rules of multiplication. Uniqueness of unity and inverses. Subrings. Subring test. Examples of subrings. Center of a ring. Zero divisors. Definition and examples of integral domains. Definition and examples of fields. Properties of integral domains and fields. Characteristic of a Ring. Characteristic of an Integral Domain. Subfields.

14 hours

Definition and examples of ideals. Ideal test. Factor Rings (also called quotient rings). Definition and examples of prime ideals and maximal ideals. Necessary and sufficient conditions for an ideal to be prime or maximal. Definition and examples of ring homomorphisms and isomorphisms. Properties of ring homomorphisms. Kernels are ideals. First Isomorphism theorem for rings. Ideals are kernels. Homomorphisms involving Z, Z_n and rings with unity.

14 hours

Unit II: CALCULUS OF VARIATION

Variation of a function *f=f(x,y,y')* variation of the corresponding functional. Extremal of a functional. Variational problem. Euler's equation and its particular forms. Examples. Standard problems like geodesics. Minimal surface of revolution. Hanging chain. Brachistochrone problem. Isoperimetric problems.

14 hours

Suggested distribution of lecture hours:

1. Algebra: 2 hours per week.
2. Calculus of Variation: 1 hour per week.

Text Books

1. Joseph Gallian, Contemporary Abstract Algebra, 8th ed. Cengage, 2018.
2. R Weinstock, Calculus of Variation with Application to Physics and Engineering, Dover, 1974.

Reference Books

1. S K Mapa, Higher Algebra: Abstract and Linear, 14th ed. Levant Books, India.
2. Vashista, A First Course in Modern Algebra, 11th ed.: Krishna Prakasan Mandir, 1980.
3. John B Fraleigh, A First Course in Abstract Algebra, 3rd ed.: Narosa Publishing House., 1990.
4. F B Hildebrand, Methods in Applied Mathematics, 1st ed. Prentice-Hall., 1952.

BluePrint (2 hours exam):

	Unit I	Unit II	Answering	Total
2 Marks (Part A)	2*+3**	1*+2**	6/8	12
6 Marks (Part B)	3*+4**		5/7	30
6 Marks (Part C)		2*+3**	3/5	18

***Pre-midterm** ****Post-midterm**

Caution: The blue print is only suggestive of the probable marks distribution and it is not binding on the examiner.

PRACTICAL

MT5P1: Mathematics Practical – V	
Practical Hours: 4 Hours/Week	Credits: 2
Total Practical Hours: 44Hours	Max.Marks:50 (S.A: 25+I.A: 25)

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on algebra and calculus by using FOSS.
- Acquire knowledge of applications of algebra and calculus through FOSS

Practical/Lab Work to be performed in Computer Lab.

Suggested Software: Python.

Practical -V

1. To check if a given ring is a commutative ring with unity.
2. To check if a given ring is an integral domain or field.
3. To check if a given subset is a subring or an ideal.
4. To check if a given ideal is a prime ideal.
5. To check if a function is a ring homomorphism and to find its kernel and image.
6. To check if a ring homomorphism is an isomorphism.
7. Euler's equation and its particular forms.
8. Brachistochrone problem
9. Minimum surface of revolution and hanging chain problem.
10. Isoperimetric problem.

MT5223: Mathematics – VI	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours:42 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to:

- View complex numbers algebraically and geometrically.
- Understand the concepts of complex differentiation and analycity of complex functions.
- Evaluate complex contour integrals using the Cauchy's integral theorem and the various versions of Cauchy's integral formula.
- Understand the concepts of gradient, divergence and curl with their geometric interpretations and their properties.
- Understand orthogonal curvilinear coordinate systems.

Unit I: COMPLEX ANALYSIS

a) Complex Numbers and Complex functions

Complex Numbers and their properties. Geometrical representation of a complex plane. Polar form of Complex numbers. Complex powers. Complex Functions: Limits and continuity.

4 hours

b) Analytic Functions and Conformal Mappings

Differentiability and Analyticity. Necessary and sufficient conditions for analyticity. Cauchy-Riemann Equations (cartesian and polar form). Harmonic Function (cartesian and polar form). Harmonic conjugate. Construction of Analytic function by Milne-Thomson's method (cartesian and polar form).

Conformal Mapping-Some standard transformations: Reflection, Translation, Magnification and Rotation, Inversion. Orthogonal system. Special conformal mapping. Bilinear Transformation: Circle-Preserving property, Mapping Lines to Circles, Fixed points, Cross - Ratio of four points.

14 hours

c) Complex Integration

Complex Integrals (Contour Integration) and their properties. Cauchy's Integral theorem and Cauchy's Integral Formula, Cauchy's Integral formula for derivatives, Consequences of Cauchy's Formula. Cauchy's Inequality, Liouville's Theorem, Fundamental Theorem of Algebra.

10 hours

Unit II: VECTOR DIFFERENTIAL CALCULUS

Scalar field. Gradient of a scalar field - Geometrical meaning, Directional derivative, Maximum directional derivative, Angle between two surfaces. Vector field-Divergence, Laplacian of a scalar field and curl of a vector field, conservative vectors. Introduction to Orthogonal Curvilinear Co-ordinates.

14 hours

Suggested distribution of lecture hours:

1. Complex Analysis: 2 hours per week.
2. Vector Differential Calculus: 1 hour per week.

Blueprint (2 hours exam):

	Unit I	Unit II	Answering	Total
2 Marks (Part A)	2*+3**	1*+2**	6/8	12
6 Marks (Part B)	3*+4**		5/7	30
6 Marks (Part C)		2*+3**	3/5	18

***Pre-midterm** ****Post-midterm**

Caution: The blue print is only suggestive of the probable marks distribution and it is not binding on the examiner.

Note: The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

Text Books

1. Dennis Zill and Patrick Shanahan, A first course in Complex Analysis, with applications, Jones and Bartlett Publishers.
2. M. D. Raisinghania, Vector Calculus, S Chand Co. Pvt. Ltd., 2013

Reference Books

1. R V Churchil and J W Brown, Complex Variables and Applications, 5th ed., McGraw Hill Companies., 1989.
2. A R Vashista, Complex Analysis, Krishna PrakashanaMandir, 2012.
3. B Spain,Vector Analysis , ELBS, 1994
4. D E Bournesand, P C Kendall, Vector Analysis, ELBS, 1996.
5. John Mathews and Russell Howell, Complex Analysis for Mathematics and Engineering, 6th ed., Jones and Bartlett Learning.
6. James Stewart, Calculus: Early Transcendentals, 6th ed. Thompson Higher Education
7. G B Thomas and R L Finney, Calculus and analytical geometry, Addison Wesley,1995.
8. Murray Spiegel, Vector Analysis and an introduction to Tensor Analysis,Schaum's Outlines,1959.
9. Michael Corrals and Anton Petrunin, Vector Calculus, 2013

PRACTICAL

MT5P2: Mathematics Practical – VI	
Practical Hours: 4Hours/Week	Credits: 2
Total Practical Hours: 44 Hours	Max.Marks:50 (S.A: 25+I.A: 25)

Course Learning Outcomes: This course will enable the students to

1. Learn Free and Open-Source Software (FOSS) tools for computer programming.
2. Learn the geometrical representations of gradient.
3. Can easily understand the concepts of divergence, curl in various coordinate systems.
4. Be able to analyze the various behaviors of surfaces using gradients.
5. Use Cauchy's integral theorem and formula to compute line integrals.
6. Construct analytic functions when either the real or imaginary part is given.

Suggested Software:
Python. Introduction to the software and commands related to the topic.

Practical -VI

1. A. Problems on Cauchy-Riemann equations in cartesian and polar form.
   B. Constructing analytic functions using Milne-Thomson method.
2. A. Orthogonality of the surfaces obtained from the real and imaginary parts of an analytic function.

   B. Verifying real and imaginary parts of an analytic function being harmonic in cartesian and polar coordinates.
3. Angle preserving property in a transformation and cross ratio.
4. The Bilinear transformation.
5. Examples connected with Cauchy's integral theorem.
6. To illustrate problems on Gradient, Divergence, Curl and Laplacian.
7. Vector identities- I
8. Vector identities - II
9. Gradient, Divergence, Curl and Laplacian in cylindrical coordinates.
10. Gradient, Divergence, Curl and Laplacian in spherical coordinates.

Semester – VI

MT6123: Mathematics – VII	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 42 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to:

- Identify a subset is a subspace with respect to the operations of vector space.
- Check if the given subset of a vector space is linearly independent, linearly dependent and a basis.
- Understand matrices and its operations in terms of linear transformations and vice-versa.
- Understand range space, null space and its significance in finding the rank of a linear transformation or rank of a matrix.
- Form, classify types of partial differential equations and solve problems involving partial differential equation.
- Identify homogeneous partial differential equation and solve using standard procedure.

Unit I: LINEAR ALGEBRA

Introduction. Vector Spaces and Examples, Subspaces and Examples, Criteria for a subset to be a Subspace, Problems. Linear Combination of Vectors, Linear Span of a Subset and Problems. Linear Dependence and Independence of Vectors, Examples and Problems. Basis and Dimension of a Vector space, The Replacement Theorem (without proof) and Problems.

14 hours

Linear Transformations, Null Space and Range Space of a Linear Transformation, The Rank-Nullity Theorem and Problems. Ordered Basis, The Co-ordinate Vector of a Vector relative to an Ordered Basis, Problems on Matrix Representation of a Linear Transformation, Composition of Linear Transformations, Invertibility of a Linear Transformation and Isomorphisms, Problems on Change of Co-ordinate Matrix.

14 hours

Unit II: PARTIAL DIFFERENTIAL EQUATIONS

Total Differential Equations. Necessary condition for the equation P dx + Q dy + R dz = 0 to be integrable. Simultaneous Equations. Formation of Partial Differential Equations. Lagrange's Linear Equation. First order Non-linear Partial Differential Equation and their solution by Charpit's Method. Types (I, II, III, Clairaut's) of First order Non-linear Partial Differential Equations. Second order PDE – Classification, Solution of Homogeneous Equations in two variables with constant coefficients.

14 hours

Suggested distribution of lecture hours:

1. Linear Algebra: 2 hours per week.
2. PDE: 1 hour per week.

Text Books:

1. S. H. Friedberg, A. J. Insel and L. E. Spence, Linear Algebra: 4th Edition, Pearson Publications, 2013.
2. M. D. Raisinghania, Ordinary and Partial Differential Equations, S Chand and Co. Pvt. Ltd., 2014.

Reference Books

1. S. Lipschutz and M. L. Lipson, Schaum's Outline of Linear Algebra: 4th Edition, Mc-Grow Hill Companies, Inc., 2013.
2. V. Sundarapandian, Ordinary and Partial Differential Equations, Tata McGraw-Hill., 2013.
3. O. Bretscher, Linear Algebra with Applications: 5th Edition, Pearson Publications, 2012.
4. G. Strang, MIT open courseware (http://ocw.mit.edu/courses).

5. Lokenath Debnath, Linear Partial differential equation for Scientists and Engineers,Fourth Ed., Birkhauser, 1997

Blueprint (2 hours exam):

	Unit I	Unit II	Answering	Total
2 Marks (Part A)	2*+3**	1*+2**	6/8	12
6 Marks (Part B)	3*+4**		5/7	30
6 Marks (Part C)		2*+3**	3/5	18

***Pre-midterm** ****Post-midterm**

Caution: The blue print is only suggestive of the probable marks distribution and it is not binding on the examiner.

Note: The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT6P1: Mathematics Practical – VII	
Practical Hours: 4Hours/Week	Credits: 2
Total Practical Hours: 44Hours	Max.Marks:50 (S.A: 25+I.A: 25)

Course Learning Outcomes: This course will enable the students to:

- Learn Free and Open-Source Software (FOSS) tools for computer programming.
- Solve problems on algebra and calculus by using FOSS.
- Acquire knowledge of applications of algebra and calculus through FOSS.

Practical/Lab Work to be performed in Computer Lab.

Suggested Software: Python.

Practical - VIII

1. Checking if the given vector is in the span of a given set.
2. a) Linear dependence and independence of vectors.
   b) Basis and dimension.
3. Verifying whether a given transformation is linear.
4. a) Finding the matrix of a linear transformation.
   b) Finding the linear transformation when the matrix and bases are given.
5. Rank and nullity of a linear transformation.
6. Solutions of first order partial differential equation.
7. Solutions to the problems on different types (I, II, III, Clairaut's) of Partial differential equations.
8. Solving second order linear partial differential equations in two variables with constant coefficients.
9. Solution of Laplace equation using Fourier series with Dirichlet condition.
10. Solution of one dimensional heat and wave equations using Fourier series with Dirichlet condition.

MT6223: Mathematics – VIII	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 42 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to

- Evaluate Line and Multiple integrals in various coordinate systems.
- Learn to compute areas, surface areas and volumes using integrals.
- Apply Green's, Stokes and Gauss Divergence Theorems.
- Learn the theory of the Riemann integral and derive some standard integrals from first principles.
- Check whether a given function is integrable or not.

UNIT I: Line and Multiple Integrals

Double integrals over rectangles (constant limits), double integrals as volume, changing the order of integration (constant limits), double integrals over bounded non-rectangular region (variable limits), finding limits of integration, changing the order of integration (variable limits), areas of bounded regions in a plane, average value using double integral, double integral in polar coordinates, triple integrals in rectangular coordinates, volume of a region in space, triple integral in polar coordinates, substitutions in multiple integrals (Jacobian). Related problems.

14 Hours

Line integrals, line integrals of vector fields, path independence, Green's theorem in a plane, using Green's theorem to evaluate line integrals, surface integrals, Stokes theorem, Gauss divergence theorem. Related problems.

14 Hours

UNIT II: Riemann Integration

Partitions of closed bounded intervals. Upper and Lower sums and integrals. Definition of integrability. Checking for integrability of functions. Inequalities for integrals. Refining a partition. Criteria for integrability (without proof). Algebra of integrable functions (showing sum, difference, product etc of integrable functions are integrable). Continuous and Monotonic functions are integrable. Definition of primitive. Fundamental Theorem of Calculus. Related Problems.

14 Hours

Text Books:

1. Joel Hass, Christopher Heil and Maurice Weir, Thomas' Calculus, fourteenth edition, Pearson, 2018.
2. S C Malik and Savita Arora, *Mathematical Analysis*, second edition, New Age International pvt limited, 2005.

References:

1. Robert G Bartle and Donald R Sherbert, *Introduction to Real Analysis*, Wiley, 2011.
2. S K Mapa, *Introduction to Real Analysis*, eighth edition, Levant Books, 2019.
3. Kenneth A. Ross, Elementary Analysis; The theory of calculus, Springer International Edition,2013.
4. Terrance Tao, Analysis-I, Trim Series, 2016.

Blueprint (2 hours exam):

	Unit I	Unit II	Answering	Total
2 Marks (Part A)	2*+3**	1*+2**	6/8	12
6 Marks (Part B)	3*+4**		5/7	30
6 Marks (Part C)		2*+3**	3/5	18

***Pre-midterm** ****Post-midterm**

Caution: The blue print is only suggestive of the probable marks distribution and it is not binding on the examiner.

Note: The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 75% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT6P2: Mathematics Practical – VIII	
Practical Hours: 4 Hours/Week	Credits: 2
Total Practical Hours: 44 Hours	Max.Marks:50 (S.A: 25+I.A: 25)

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on algebra and calculus by using FOSS.
- Acquire knowledge of applications of algebra and calculus through FOSS

Practical/Lab Work to be performed in Computer Lab.

Suggested Software: Python.

Practical - VIII

1. Evaluation of the line integrals.
2. A. Evaluation of the double integral with constant limits.

   B. Evaluation of the double integral with variable limits.
3. A. Evaluation of the triple integral with constant limits.

   B. Evaluation of the triple integral with variable limits.
4. Computing area, surface area and volume.
5. Verifying Green's theorem.
6. Verifying Gauss divergence theorem.
7. Verifying Stoke's theorem.
8. Computing Lower and Upper sums of functions for various partitions and refinements.
9. Verifying Inequalities involving integrals.
10. Verifying Fundamental Theorem of Calculus and Mean Value Theorems.